Attitudes on Gain and Loss Lotteries: A Simple Experiment

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5 March 2004

Abstract: A new definition of loss aversion is proposed and tested. Thirty-one students participated in experiments on lotteries involving small scale real gains and losses. At the aggregate level, approximately 60% of the choices are in the direction of loss aversion. The analysis at the individual level shows that, compared to loss seekers, more than twice as many are loss averters, the remaining subjects being unclassified. Comparing these results with risk behavior involving gain only lotteries shows a strong polarization effect: when loss outcomes are introduced, a majority of subjects shift from unclassified risk attitude in the domain of gains towards loss aversion, but some exhibit loss seeking. A strong gender effect is also observed. Proportionally more women are sensitive to losses. There is statistical evidence that in these binary choices the sign of common outcomes has influence on choice behavior, which is in contrast to the predictions of comonotonic independence, the core principle of rank-dependent utility theories.

Keywords: Binary Choice, Comonotonic Independence, Gender Effect, Loss Aversion, Risk Aversion.

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*The first author acknowledges financial support from an ESRC studentship. Financial support for undertaking these experiments from the University of Manchester Small Research Grant Scheme are acknowledged.

1 Introduction

Loss aversion can explain behavior that has been viewed as anomalous according to classical utility theory. Examples are the endowment effect (Thaler 1980, Loewenstein and Adler 1995), the status quo bias (Samuelson and Zeckhauser 1988), the disparity between the willingness to pay and the willingness to accept (Kahneman, Knetsch, and Thaler 1990, Bateman, Munro, Rhodes, Starmer, and Sugden 1997), and the disposition effect (Weber and Camerer 1998, Odean 1998, Heat, Huddart, and Lang 1999), who have all been attributed to the presence of loss aversion. Rabin (2000) proves that expected utility is unable to account for the empirically observed degrees of risk aversion for small and moderate stakes. Rabin (p. 1288) suggests that loss aversion may be a better explanation for this paradox. This point is reiterated in Rabin and Thaler (2001, p. 226) who propose loss aversion plus mental accounting (Thaler 1999) as explanations for the evidence on risk aversion. The tendency of people to evaluate prospects in isolation, taken in combination with loss aversion, can explain the equity premium puzzle (Benartzi and Thaler 1995). The empirical evidence paired with recent theoretical advances, shows that models that permit for loss attitudes have become important in economic applications (Camerer 1998, Kahneman and Tversky 2000, Starmer 2000, Barberis and Thaler 2003, Camerer, Loewenstein, and Rabin 2004).

The empirical evidence confirms that people exhibit stronger sensitivity towards prospects involving losses than towards prospects involving only gains. Disliking symmetric fair bets has already been mentioned by Markowitz (1952), who attributes this to the disproportional utility of the symmetric outcomes. Edwards (1955) observed that probability distortions depend on the sign of the outcomes. Later, it was suggested that the utility function is the sole carrier of loss attitudes (Fishburn 1977, Kahneman and Tversky 1979, Holthausen 1981), whereas in Tversky and Kahneman (1992) both, probability distortions and utility, were capturing such sensitivity (see also Abdellaoui 2000). The generally accepted view is that a potential loss is perceived as more harmful than an equally likely gain of the same magnitude is perceived to give pleasure. Note that this intuitive property does not require disentangling probability weighting and utility. Further, it is a local property in the sense that it is concentrated at sensitivity to deviations from the status quo. Kahneman and Tversky (1979, p. 279) have added a further aspect, namely that such sensitivity is increasing with the size of the symmetric stakes. They then showed that, under their prospect theory, the utility function is capturing all effects of loss aversion, leading to the well known statement of utility being "steeper for losses than for gains." However, even this second aspect of loss aversion does not require a separation of probability weighting and utility, as it is a behavioral property that can easily be verified.

The goal of this paper is to provide evidence for the presence loss aversion as described by this latter behavioral aspect. We view any such evidence as a direct confirmation of loss aversion. The experimental results related to verifications of the above mentioned expected utility paradoxes can be viewed as indirect evidence for the presence of loss aversion. Other experiments focusing on estimations of utility and probability weighting functions can also be classified as indirect tests of loss aversion. The reason for this is that a specific decision model where utility and weighting functions are separated is initially assumed (e.g. Edwards 1955, Currim and Sarin 1989, Hogarth and Einhorn 1990, Tversky and Kahneman 1992, Schmidt and Traub 2002).

Implications for loss attitudes have also been derived by comparing risk behavior in the gain domain with the behavior in the loss domain (Fishburn and Kochenberger 1979, Hershey and Schoemaker 1985, Schneider and Lopes 1986, Starmer and Sugden 1989, Camerer 1989, Currim and Sarin 1989, Hogarth and Einhorn 1990, Tversky and Kahneman 1992, Abdellaoui 2000, Laury and Holt 2000, Barron and Erev 2000, Smith, Dickhout, McCabe, and Pardo 2002, Harbaugh, Krause, and Vesterlund 2002). This does however bring up the issue of how behavior in the gain domain and separately the behavior in the loss domain can be combined to predict the effect of loss attitude in the domain where gains and losses occur jointly. We argue that a direct test of loss aversion through binary choices requires a comparison of lotteries with mixed outcomes (i.e., containing gains as well as losses). Studies that involve mixed outcome lotteries are less frequent and usually involve non-symmetric outcomes (e.g., Grether and Plott 1979, Harless 1992, Fennema and Wakker 1997, Loehman 1998, Benartzi and Thaler 1999). Exceptions are Battalio, Kagel, and Jiranyakul (1990) and Schoemaker (1990) where the local aspect of loss aversion, namely aversion to symmetric 50:50 lotteries, is explicitly tested. Thaler and Johnson (1990) also use 50:50 symmetric gambles to analyze how behavior is influenced by prior gains or losses. We proceed by initially proposing a behavioral definition of loss aversion, where potential losses need to be traded off against equally likely gains of the same magnitude. Subsequently we present the results of an experiment testing this property.

This is how loss aversion is understood in this paper. Suppose we have a lottery that gives equal probability to the best and worst outcome, and that these outcomes are, respectively, a gain and a loss of equal size. From this lottery a second one can be generated by reducing the worst outcome by an amount that is added to the best outcome. Loss aversion is manifested as a preference for the first lottery. This can be viewed as aversion to specific mean preserving spreads (Rothschild and Stiglitz 1970), also called aversion to monotonic mean preserving spreads in Quiggin (1992), however, with the restriction that the outcomes involved in the monetary transfer must be the worst loss and best gain outcomes.

Note that, with this definition of loss aversion, comonotonic independence (Schmeidler 1989, Gilboa 1987, Wakker 1989, Chew and Wakker 1993, Wakker and Tversky 1993, Wakker 1994), the unifying principle of rank-dependent utility theories, requires that the preference is independent of the common outcomes of the two lotteries. An aspect of the experiment here is that we vary the sign of the common outcomes in the lotteries and can observe whether this has any impact on loss attitude. According to comonotonic independence the direction of preference should be governed only by loss attitude. Consequently, we draw conclusions concerning the validity of comonotonic independence. As we do not disentangle utility from probability, only the joint impact of outcomes and probability can be observed. We do, however, vary the probabilities so that inference can be made on whether the likelihood of opposite outcomes has any effect on loss attitudes.

In this experiment we use real stakes. Using real stakes instead of hypothetical ones has the benefit of creating less erroneous choices (Smith and Walker 1993, Camerer and Hogarth 1999). To generate real losses we pay subjects a fixed amount from which they can lose (or gain). We frame this as compensation for their effort. This is similar to other studies in the domain of losses (Camerer 1989, Battalio, Kagel, and Jiranyakul 1990, Harless 1992, Myagkov and Plott 1997, Smith, Dickhout, McCabe, and Pardo 2002). An exception is Benartzi and Thaler (1999) who do not offer an initial payment but instead the option of earning money if losses exceed a certain level. Laury and Holt (2000) introduce an initial task in which participants can build up a stake before they go on to choose among lotteries involving losses. This way, they argue, participants integrate the stakes more quickly into their current wealth, thereby avoiding a “house money” effect (Thaler and Johnson 1990) that was observed in Battalio, Kagel and Jiranyakul (1990).

In our study each participant received a fixed amount of £10. In addition a lottery selected randomly among their choices is played for real (see Cubitt, Starmer and Sugden (1997) for a discussion on this technique). The stakes in the lotteries varied from £-10 to £15. The binary choices are presented in isolation and in individually randomized order without subjects previously having information about the payoff structure of the lotteries. In this experiment we therefore rely on the presence of the isolation effect (Kahneman and Tversky 1979).

The results of the experiment indicate that loss aversion is a dominant feature among the participants in this study. We give a brief summary here. At the aggregate level and across all loss attitude tasks 60.14% of the choices are in the direction predicted by loss aversion. Of the 31 individuals a binomial test classifies 8 subjects as loss seekers, and 17 as loss averters, the remaining 6 being left unclassified. A separation according to gender indicates that, of the 18 males, 7 are loss seekers and 8 are loss averters. The 13 females are divided into 1 loss seeker and 9 loss averters. A random effects probit regression model shows that gender has a highly significant influence on loss attitudes, and similarly the sign of the common outcomes in the lotteries within a task has significant influence. There is no significant difference between loss attitudes in tasks where the symmetric outcomes have probability 1/3 and tasks in which the symmetric outcomes have probability 1/4.

The structure of the paper is as follows. In the next section some useful notation and the formal definition of loss aversion is presented. Section 3 offers details about the experiment and Section 4 the results on loss aversion, first at the aggregate level, and then at the individual level. Section 5 compares the classification of subjects according to their risk behavior on choices involving only gain lotteries, with the classification of risk behavior involving mixed lotteries. Gender effects are discussed in Section 6, whereas Section 7 looks at the issue of comonotonic independence. We conclude with a discussion in Section 8. The Appendix contains details about the instructions for the participants and details about the lotteries involved in the binary choices.

2 A Definition of Loss Aversion

A *lottery* is a finite probability distribution over the set of monetary outcomes (here identified with the set of real numbers, $I\!R$). It is represented by $P := (p_1, x_1; \ldots; p_n, x_n)$ meaning that probability p_j is assigned to outcome x_j, for $j = 1, \ldots, n$. The probabilities p_j are nonnegative and sum to one. With this notation we implicitly assume that outcomes are ranked in decreasing order, i.e., $x_1 \geqslant \cdots \geqslant x_k \geqslant 0 > x_{k+1} \geqslant \cdots \geqslant x_n$ for some $0 \leqslant k \leqslant n$. Outcomes are interpreted as deviations from the *status quo*, here identified with 0. Hence, positive outcomes are called *gains* and negative outcomes are *losses*. A *gain lottery* has only nonnegative outcomes ($k = n$), whereas a *loss lottery* only nonpositive outcomes ($k = 0$). A *mixed lottery* contains at least a gain and a loss.

Expected Utility (EU) holds if an individual evaluates lotteries according to:

$$EU(p_1, x_1; \ldots; p_n, x_n) = \sum_{i=1}^{n} p_i U(x_i),$$

where U is the utility function. The utility function U is assumed strictly increasing and continuous with $U(0) = 0$. Under EU the utility function is a ratio scale, that is, it is unique up to multiplication by a positive constant. In contrast to the traditional interpretation we assume that U is defined on gains and losses and not on final wealth positions. This allows us to analyze loss attitudes in the EU model.

In the original version of *prospect theory* (OPT) there exists a *weighting function* w (i.e., $w : [0,1] \to [0,1]$, strictly increasing with $w(0) = 0$ and $w(1) = 1$), such that lotteries are evaluated by

$$OPT(p_1, x_1; \ldots; p_n, x_n) = \sum_{i=1}^{n} w(p_i) U(x_i).$$

This formula applies only to mixed lotteries. Actually, Kahneman and Tversky (1979) proposed OPT only for lotteries with three outcomes of which one equals zero. Here we use the extension to general lotteries, for instance as used by Camerer and Ho (1994) and Fennema and Wakker (1997). Recall that under OPT the weights involved in the evaluation of a lottery are direct transformations of the probabilities, an aspect that was criticized because it leads to violations of stochastic dominance (Fishburn 1978).

The modern version of prospect theory, called *cumulative prospect theory* (CPT), differs from OPT by involving two weighting functions w^+, w^-, and moreover, the weights used in the evaluation of lotteries are differences in decumulative, respectively, cumulative probabilities. All lotteries are evaluated by

$$\begin{aligned} CPT(p_1, x_1; \ldots; p_n, x_n) &= \sum_{i=1}^{k} [w^+(p_1 + \cdots + p_i) - w^+(p_1 + \cdots + p_{i-1})] U(x_i) \\ &\quad + \sum_{i=k+1}^{n} [w^-(p_i + \cdots + p_n) - w^-(p_{i+1} + \cdots + p_n)] U(x_i). \end{aligned}$$

The utility function under CPT is similar to that under EU, and the weighting functions are uniquely determined. For axiomatic derivations of CPT see Luce

(1991), Luce and Fishburn (1991), Tversky and Kahneman (1992), Tversky and Wakker (1993) and Chateauneuf and Wakker (1999), Luce (2000).

Let us now proceed with the definition of loss aversion as tested in this paper. Note that this definition includes as a special case aversion to 50:50 symmetric gambles (Markowitz 1952, Kahneman and Tversky 1979).

Definition 1 *Loss aversion holds if for all $x > y \geqslant 0$ and $0 < q \leqslant 0.5$, we have*

$$(q, x; p_2, z_1; ...; p_{n-1}, z_{n-1}; q, -x) \prec (q, y; p_2, z_1; ...; p_{n-1}, z_{n-1}; q, -y).$$

Loss neutrality (seeking) holds if we replace the strict preference in the above relation with indifference, $\sim$ (reversed strict preference, $\succ$).

Observe that in the above definition the left lottery results from the right one by a monetary transfer at extreme outcomes, that is $(x - y)$ from the worst outcome is shifted to the best outcome. The condition therefore says that a loss averse individual values the potential marginal gain of $x-y$ less than the potential marginal loss of $x-y$ at extreme symmetric outcomes. The special case when $q = 0.5$ and $y = 0$ shows that the above definition strengthens aversion to 50:50 symmetric lotteries. Loss aversion is fully determined by comparing symmetric extreme outcomes, and therefore independent of the remaining outcomes in the lotteries, which are common. This feature is an aspect of comonotonic independence, the central condition of rank-dependent utility theory.

Loss aversion is related to aversion to mean preserving spreads, in short MPS, (see Rothschild and Stiglitz 1970). One can view the left lottery in the definition above as adding a symmetric $q : q$ lottery of mean 0 to the right lottery, namely $(q, x-y; 1-2q, 0; q, y-x)$. In this sense the left lottery is a monotonic MPS as proposed by Quiggin (1992). The additional restrictions here are that, first a monetary transfer goes from a loss to a gain of the same magnitude. This results in a condition called strong loss aversion in Schmidt and Zank (2002), who additionally allow for common best and worst outcomes in the above definition. A second restriction is that, as noted above, the monetary transfer is tied to the extreme outcomes.

As noted in the introduction loss aversion is a behavioral concept and hence does not depend on the identification of utility by using a specific decision model. We can, however, look at the implications of loss aversion under EU, OPT, and CPT, respectively. It turns out that in the framework of prospect theory or expected utility theory (that is OPT with a linear weighting function for probabilities) loss aversion is equivalent to the fact that the utility function is steeper for losses than for gains, such that we may have a kink of the utility function at the status quo. This result follows immediately from substitution of the corresponding functional form, and is summarized in Proposition 2.

PROPOSITION 2 *Under EU and OPT loss aversion is satisfied if and only if for all* $x > y \geqslant 0$ *it holds that* $U(x) - U(y) < U(-y) - U(-x)$. □

The above proposition shows that the statement "utility is steeper for losses than for gains" remains valid under OPT. This is different for CPT, as the next proposition shows. Again, the result follows directly by substitution of the CPT-functional and cancellation of common terms.

PROPOSITION 3 *Under CPT loss aversion is satisfied if and only if for all* $x > y \geqslant 0$ *and* $q \in (0, 1/2]$ *it holds that* $w^+(q)[U(x) - U(y)] < w^-(q)[U(-y) - U(-x)]$. □

This result shows that under CPT the impact of loss aversion is explained by both, utility and probability weighting. This has also been confirmed by experimental studies (Edwards 1955,, Currim and Sarin 1989, Tversky and Kahneman 1992, Abdellaoui 2000, Abdellaoui, Vossman, and Weber 2003) and indicated in Camerer and Ho (1994, note 18). Under CPT the ratio between the probability weighting functions over $(0, 1/2]$ gives a lower bound for the ratio between marginal utility at symmetric outcomes. This is similar to Schmidt and Zank (2002) and Zank (2003) who analyze stronger, respectively, weaker loss aversion conditions under CPT. With these remarks on the theoretical implications we can move on to present details about our experiment in the next section.

3 Experiment

Thirty-one graduate and undergraduate students in economics from the University of Manchester took part in this study. The participants had knowledge about the concept of expected value and expected utility. They were initially sent an e-mail message asking them to respond if they are interested in participating in an experiment about risky choices, where they would be compensated for their effort. This message contained a link to a web-page that displayed the instructions of the experiment. We have channeled respondents to attend the experiment at particular times during April and May 2003.

The experiment was held on computers using a standard web interface familiar to students. Initially, the experimenter read aloud the instructions that explained the nature of the experiment and the method used to reward participants. Participants were informed that they had to respond to 106 tasks, and that afterwards they were rewarded depending on their decision in a randomly selected task. It was explained that a task consisted of choosing between two gambles, and that indifference was not allowed. A gamble was framed as picking a ball from a bag that contains 12 equally likely balls numbered consecutively from 1 to 12. A gamble was visualized on the screen as 12 colored balls with amounts of money underneath balls of the same color. Two sorts of gambles were used. In the first one balls 1-4, 5-8, and 9-12, had colors green, red, and blue, respectively, whereas in the second gamble balls 1-3, 4-9, and 10-12, had colors pink, brown, and orange, respectively. It was mentioned that in a task both gambles would have the same colored balls. An example of a task is presented below.

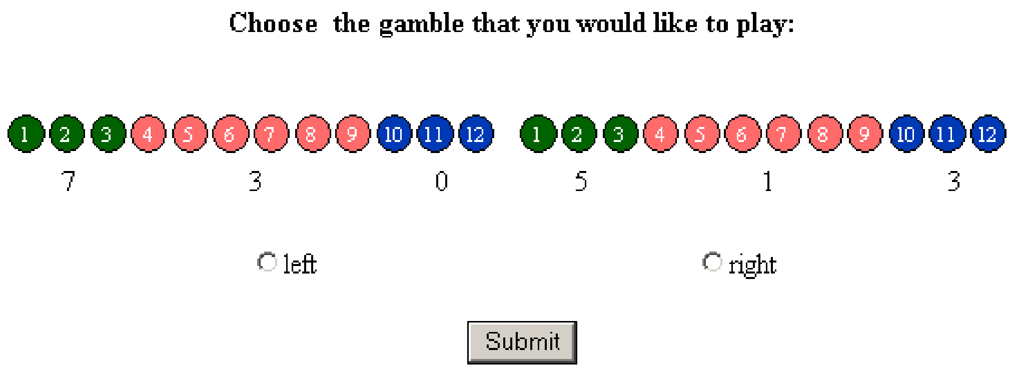

Figure 1: Example of a Task

Participants were told that the amounts of money in the gambles are in the range £−10-£15, and that their final payment was made up of a fixed amount (£10) that they would get if they answer all tasks, plus the outcome of the randomly selected gamble. Full instructions are available in the Appendix.

Subsequently, participants were asked to proceed with the experiment by activating a link to a further web-page. The window with the instructions was accessible throughout the experiment. Participants were asked details about their student registration number, degree of study, gender, and nationality. After submitting this information the first binary choice appeared on the screen. In addition to the recorded choice, we did also record the time at which the answer to each task was submitted. After responding to 106 choices, participants were asked for comments about the experiment and potential decision rules that they were using. Following that a randomly selected lottery among the participants choices displayed on the screen, and was played out as indicated in the instructions. The outcome was added to the fixed payment, and later a cheque was sent to the participant.

The experiment consisted of 96 tasks plus 10 repeated tasks selected at random. The outcomes of the lotteries in all tasks are available in the Appendix. Each participant received the tasks in an individually randomized order. Further, the position of the left and right lotteries was tied to whether the time on the computer was indicating seconds 1-30 or 31-00. Moreover, care was taken to avoid having the outcomes in a task ranked in a systematic way (e.g., from best to worst in both lotteries).

The first 48 tasks involve only mixed lotteries, whereas tasks 49-96 are looking at gain lotteries. Tasks 1-24 and 49-72 are using the probability distribution $(1/3, 1/3, 1/3)$, which is termed the *equally likely* (EL) condition, whereas tasks 25-48 and 73-96 are using the probability distribution $(1/4, 1/2, 1/4)$, termed the *non-equally likely* (NEL) condition. The role of the latter 48 tasks is two-fold. First, these tasks are filler tasks used to complement the loss aversion tasks which are quite transparent in their design of considering lotteries with two symmetric outcomes and one further outcome that is common to the two lotteries. Secondly, 25 of these are tasks where one lottery is an MPS of the other one, which we used to classify individuals according to risk attitudes on gains. In contrast tasks 1-48 allowed a classification of individuals into loss attitude. In each loss attitude task the two extreme outcomes of the lotteries differed, respectively, by exactly £1. That is, in the EL-condition the choice was between

$$(1/3, x; 1/3, z; 1/3, -x) \text{ and } (1/3, x-1; 1/3, z; 1/3, 1-x)$$

whereas in the NEL-condition the choice was between

$$(1/4, x; 1/2, z; 1/4, -x) \text{ and } (1/4, x-1; 1/2, z; 1/4, 1-x).$$

This way, in each loss attitude task, participants were trading off a potential additional gain against a potential additional loss, both of £1. A further distinction within both conditions is that the tasks fall into different categories depending on the sign of the common outcome in the lotteries. The common outcome, z in the above notation, varies from being the status quo, a loss, or a gain.

Taken together, this design allows us to provide evidence for several questions:

1. Are the participants providing reliable answers?

2. What is the proportion of loss averse choices?

3. How many individuals can be classified as loss seekers or averters, and how do these numbers compare to the corresponding classifications according to risk attitude?

4. Does the behavior of individuals change in the transition from gain lotteries to mixed lotteries?

5. Are there any gender effects?

6. Is the behavior of individuals affected by the sign or size of the common outcomes in lotteries within a task?

The subsequent sections present results and statistical analyses regarding the above mentioned questions.

4 Results

In this section we report results regarding the consistency in choices and regarding the loss attitudes of the participants.

4.1 Consistency

Recall that the experiment comprised 96 tasks of which for each participant 10 randomly selected tasks were repeated. Therefore, a total of 310 tasks were repeated, of which 71.94% matched the initial response. Previous studies have reported similar percentages (e.g., Wakker, Erev, and Weber 1994, Camerer 1989, Weber and Kirsner 1997). The proportion of consistent answers of the male subsample was 75.56%, and that of the female subsample 66.92%. Out of the 310 repeated tasks 147 are representing loss attitude tasks. Out of these tasks 78.91% are consistent choices. The male subsample has 86.05% consistent choices (74 out of 86), whereas the female subsample has 68.85% consistent choices (42 out of 61). It can be stated that overall males provide more consistent answers than females.

As we explain below, we have used criteria to classify individuals as loss averter or loss seeker. Some individuals do not fall in either class, and could be viewed as exhibiting loss neutral behavior. The consequences of that, and the fact that individuals were not allowed to report indifference between lotteries, could be that unclassified individuals have inconsistent choices because they choose randomly when indifferent. When we exclude individuals that are not classified as loss averter nor as loss seeker, consistency increases marginally to 73.6% (184 out of 250). And when we look only at tasks involving loss attitudes 84.82% (95 out of 112) of choices are consistent. This suggests that loss neutrality may affect the consistency results, and as such the issue of reliability is less problematic for the results on loss aversion.

Similarly, below we have used criteria to classify individuals as risk averter or risk seeker over gain lotteries, and, as we report, a majority are unclassified (or close to risk neutral) in this domain. Excluding the latter individuals from the consistency analysis again improves the results: 81.33% (122 out of 150) of choices are consistent.

We do, however, provide an answer to the question whether participants who choose inconsistently are introducing a bias in the results that we report below. That is, do the results depend on whether the nonconsistent subsample is excluded from the analyses? This requires a decision rule on how to classify participants as consistent. We use a simple one-tailed binomial test for this purpose. If, out of the 10 repeated tasks, 7 or more choices are consistent with the initial choice, then we classify such an individual as consistent.[2] This excludes 11 participants from the study, however, the results for the smaller sample do not differ significantly from those of the entire population. We decided therefore that, in each of the following sections, initially we report the results for all the participants followed by remarks on potential differences when inconsistent individuals are removed.

4.2 Loss attitude

We begin this subsection by presenting the results on the loss attitude tasks (i.e., tasks 1-48) for the whole population, first at the aggregate level and then at the individual level, and further we discuss the effect of the sign of common outcomes

[2]The bound implied by having exactly 10% in the upper tail of the distribution is 7.026. Using 8 as the bound would leave 3% in the upper tail, however this would reduce the population sample to 11 individuals. Hence, we use 7 consistent answers as the benchmark.

on loss attitudes. Subsequently, we present the analogous results within the EL-condition and the NEL-condition. We conclude by looking at the results for the consistent subsample.

Tables 1 and 2 give a detailed overview on the answers to the loss attitude tasks. In each table, the first column refers to the label of task, the next three columns refer to the outcomes in the left (more spread) lottery and the last three columns indicate the outcomes of the right lottery. Columns 4 and 5 indicate the number of choices in favor of the left, respectively, right lottery. Table 1 refers to the EL-condition and Table 2 refers to the NEL-condition, both having the proportion of left, respectively, right choices presented at the bottom of the table. Overall, 60.14% of the choices are in the direction predicted by loss aversion. This is significantly different from 50% ($p < 0.001$).

Question	Left Outcomes			# Left Responses	# Right Responses	Right Outcomes		
1	10	0	-10	**10**	**21**	9	0	-9
2	9	0	-9	**11**	**20**	8	0	-8
3	8	0	-8	**15**	**16**	7	0	-7
4	7	0	-7	**12**	**19**	6	0	-6
5	6	0	-6	**11**	**20**	5	0	-5
6	5	0	-5	**12**	**19**	4	0	-4
7	4	0	-4	**11**	**20**	3	0	-3
8	3	0	-3	**11**	**20**	2	0	-2
9	2	0	-2	**15**	**16**	1	0	-1
10	10	3	-10	**13**	**18**	9	3	-9
11	9	3	-9	**14**	**17**	8	3	-8
12	8	3	-8	**17**	**14**	7	3	-7
13	7	3	-7	**11**	**20**	6	3	-6
14	6	3	-6	**9**	**22**	5	3	-5
15	10	5	-10	**12**	**19**	9	5	-9
16	9	5	-9	**14**	**17**	8	5	-8
17	8	5	-8	**15**	**16**	7	5	-7
18	7	5	-7	**16**	**15**	6	5	-6
19	10	7	-10	**10**	**21**	9	7	-9
20	10	-3	-10	**12**	**19**	9	-3	-9
21	9	-3	-9	**10**	**21**	8	-3	-8
22	8	-3	-8	**11**	**20**	7	-3	-7
23	7	-3	-7	**8**	**23**	6	-3	-6
24	6	-3	-6	**10**	**21**	5	-3	-5
		Aggregate %		**38.98**	**61.02**			

Table 1: Loss Attitude Tasks and Choices in EL-condition

Questio	Left			# Left	# Right	Right		
25	10	9	-10	**11**	**20**	9	9	-9
26	9	8	-9	**12**	**19**	8	8	-8
27	8	7	-8	**16**	**15**	7	7	-7
28	7	6	-7	**15**	**16**	6	6	-6
29	6	5	-6	**12**	**19**	5	5	-5
30	5	4	-5	**15**	**16**	4	4	-4
31	4	3	-4	**14**	**17**	3	3	-3
32	3	2	-3	**16**	**15**	2	2	-2
33	2	1	-2	**17**	**14**	1	1	-1
34	10	7	-10	**12**	**19**	9	7	-9
35	10	3	-10	**13**	**18**	9	3	-9
36	9	3	-9	**13**	**18**	8	3	-8
37	8	3	-8	**12**	**19**	7	3	-7
38	7	3	-7	**15**	**16**	6	3	-6
39	6	3	-6	**12**	**19**	5	3	-5
40	10	5	-10	**11**	**20**	9	5	-9
41	9	5	-9	**11**	**20**	8	5	-8
42	8	5	-8	**10**	**21**	7	5	-7
43	7	5	-7	**13**	**18**	6	5	-6
44	10	-3	-10	**8**	**23**	9	-3	-9
45	9	-3	-9	**8**	**23**	8	-3	-8
46	8	-3	-8	**13**	**18**	7	-3	-7
47	7	-3	-7	**14**	**17**	6	-3	-6
48	6	-3	-6	**10**	**21**	5	-3	-5
		Aggregate		**40.7%**	**59.2%**			

Table 2: Loss Attitude Tasks and Choices in NEL-condition

Looking across both tables we observe that in 43 tasks (89.58%) a majority of choices are in the direction predicted by loss aversion, and in only 5 of the 48 tasks a majority of choices are in the opposite direction (tasks 12, 18, 27, 32, 33). There is some variation in the number of choices in a particular direction. The number of loss seeking choices ranges between 8 and 17, and consequently, the number of loss averse choices ranges between 14 and 23. This indicates that, although a majority of participants may be loss averters, and some loss seekers, there may be a significant proportion of loss neutral individuals.

Loss neutral behavior may be expected for choices involving very small outcomes close to 0 but should be more pronounced as the symmetric outcomes become larger. Figure 2 indicates the probability of choosing the right less spread lottery, depending on the absolute size of the symmetric outcomes in the left lottery, using a LOWESS smoother.[3]

[3]The statistical programme STATA has been used to provide LOWESS-charts.

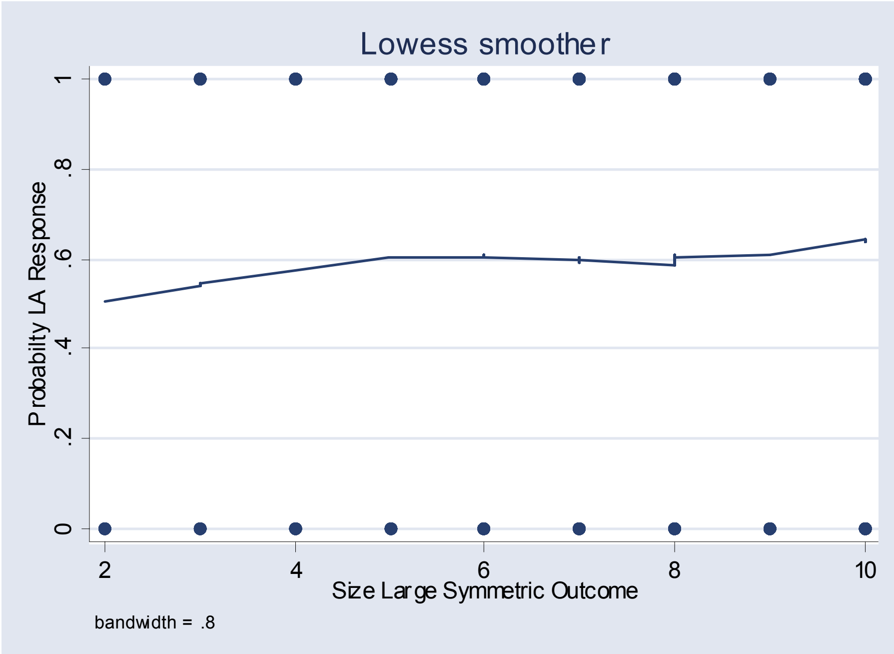

Figure 2: Graphical Output using LOWESS smoother

This figure indicates that the likelihood of choosing the right lottery in any choice is at least 50%, and that loss aversion becomes more likely as the symmetric outcomes increase. There is a jump at symmetric outcome £8 which is in contrast to the expected monotonicity of the curve. It turns out that this feature is a result of having a majority (or roughly equal proportion) of loss seeking choices in some tasks involving £8 as the symmetric outcome (tasks 3, 12, 17, 27). A closer look at these tasks revealed that some individuals switch between loss averse choice and loss seeking choice, in particular in the EL-tasks.

There is a further feature that deserves attention. The lotteries in tasks 10-14 and 35-39 have a gain, £3, as common outcome, whereas tasks 20-24 and 44-48 have a loss, £−3, as common outcome. It turns out that the proportion of loss averse choices is larger if the common outcome is negative than if the common outcome is positive (66.45% versus 58.39%). A Matched-Pairs t-test compares the mean difference between choices among tasks with common outcome £3 and those having common outcome £−3. With the null hypothesis that the mean difference is zero the test returns a p-value of 0.012. The more powerful Wilcoxon Matched-Pairs Signed-Ranks Test is looking at comparing the median difference of choices among the tasks in the two common outcome conditions, and finds little evidence for the hypothesis that the median difference is equal to zero ($p = 0.021$). Taken together this indicates that the sign of the common outcome is apparently affecting the predominance of loss aversion.

Next we discuss the results at the level of individuals. We have used the following rule to classify individuals as loss seekers, loss averters, or as unclassified (as opposed to loss neutral). A two-tailed binomial test at the 5% level requires that across the 48 loss attitude tasks at most 17 choices should be in favor of the less spread lottery in order to classify an individual as loss seeker. In contrast a loss averse individual is one that chooses in at least 31 tasks the less spread lottery. Figure 3 presents the results according to this selection criterion by indicating the number of individuals on the vertical axis against the number of choices consistent with loss aversion on the horizontal axis.

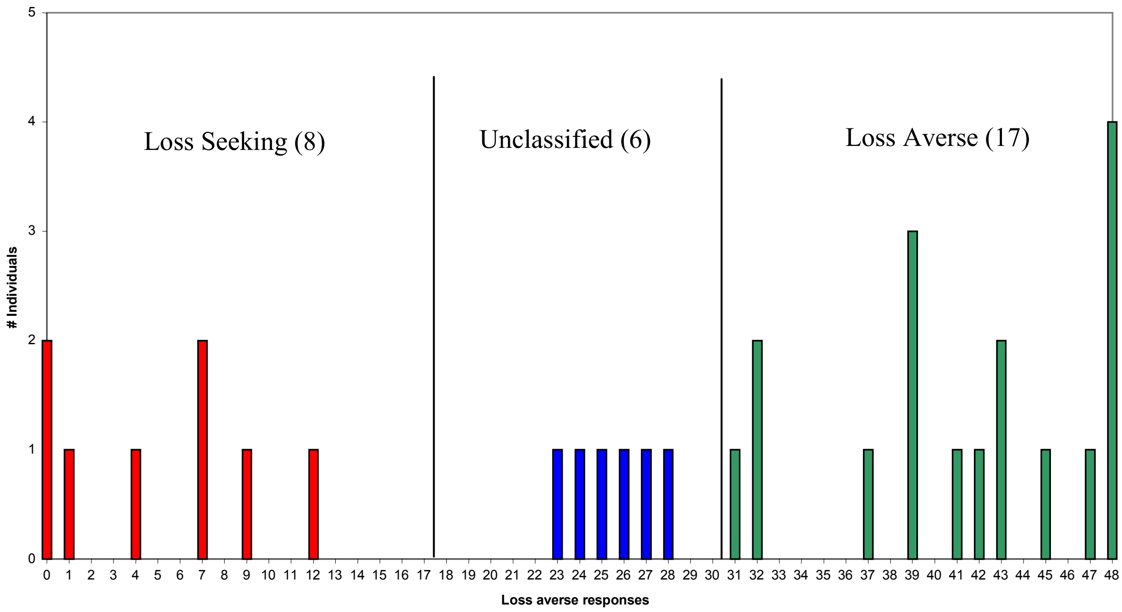

Figure 3: Classification According to Loss Attitude at 5%-level

Over the 48 loss attitude tasks 8 individuals are loss seekers and 17 are loss averters, leaving 6 participants unclassified. More than twice as many individuals are exhibiting loss aversion as opposed to loss seeking behavior, that is, the proportion of loss averse individuals (54.84%) compares favorably to the proportion of loss seekers (25.81%).

A further question that we like to investigate is whether the different probability distributions were influencing loss attitudes. The 48 loss attitude tasks are therefore divided into the equally likely (EL) condition and the nonequally likely (NEL) condition, the latter considering lotteries with probability distribution $(1/4, 1/2, 1/4)$ over it's 3 outcomes. We reconsider the above analyses by looking at these conditions separately. From Tables 1 and 2 above we observe that there is no significant difference in the proportion of loss averse choices among the conditions. In the EL-condition 61.02% of the choices are as predicted by loss aversion, and in the NEL-condition 59.27%. We employed a Wilcoxon Matched-Pairs Signed-Ranks Test to find statistical evidence for the hypothesis that the difference of the median choice among the tasks is different from zero. In this statistical test we included only tasks 10-24 and 34-48 which differ, respectively, only by the probability distribution in the lotteries. The returned p-value is 0.575, confirming that there is no significant difference between the choices in the respective conditions.

Of the 24 tasks in each condition, a majority of choices are in the direction predicted by loss aversion (91.67% in the EL-condition and 87.5% in the NEL-condition). That the probability of choosing in agreement with loss aversion increases with the magnitude of the symmetric outcome of the left lottery can be observed from Figure 4.

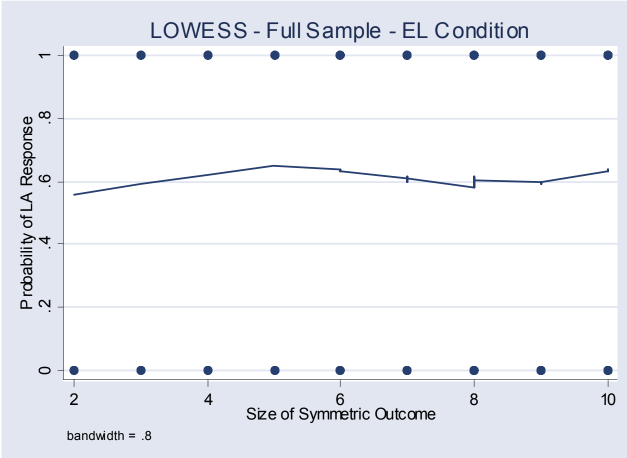

Figure 4a: EL-condition LA/Symmetric Outcome

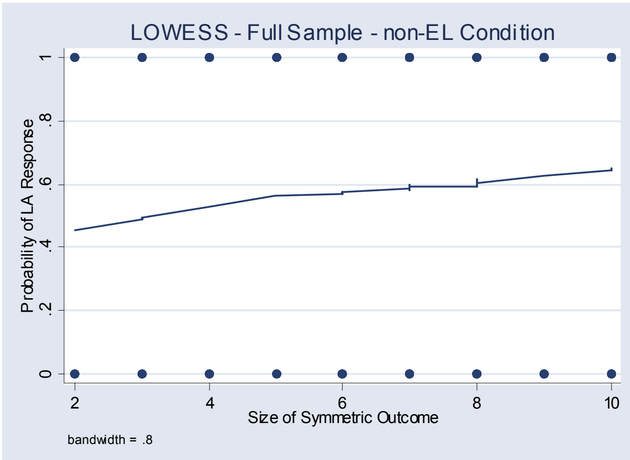

Figure 4b: NEL-condition LA/Symmetric Outcome

In both conditions loss aversion becomes more pronounced as the symmetric outcome increases and the likelihood of choosing in accordance with loss aversion is above 50%. The jump at outcome £8, which was also present in Figure 2 above, is observed only in the EL-condition (Figure 4a) confirming that the irregularity detected in Figure 2 above stems from choice behavior in the respective EL-tasks.

In both conditions there is evidence that the sign of the common outcome is influencing loss attitude. We compare behavior in 5 tasks involving common outcome £3 with behavior in 5 tasks involving common outcome £−3. In the EL-condition 56.87% of choices are loss averse when the common outcome is positive and 67.1% when it is negative. The proportions in the NEL-condition are similar: 58.06% and 65.81%, respectively. As the number of tasks in each condition is rather small, the outcome of statistical tests will not be very reliable in qualifying these differences.[4] An indication of how the common outcomes may influence the propensity of loss averse choices can be obtained by looking at a selection of the tasks in the EL-condition. There are 16 tasks with varying common outcomes -3, 0, 3, and 5. The following figure indicates the probability of an individual choosing the right less spread lottery depending on the value of the common outcomes in the lotteries using a LOWESS smoother:

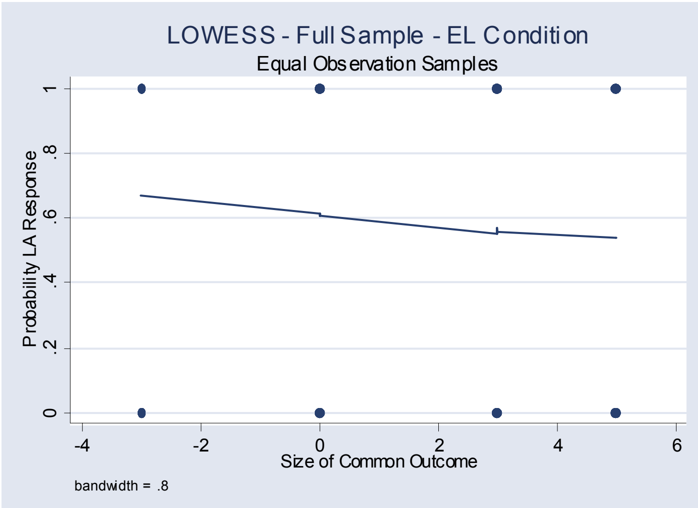

Figure 5: Loss Aversion vs. Common Outcome

The general impression from Figure 5 is that the probability of choosing in accordance with loss aversion is inversely related to the value of the common outcomes in the lotteries. For positive common outcomes this likelihood seems relatively stable above 50%, indicating that the sign of the common outcome is responsible for the increment in the proportion of loss averse choices. This point is reiterated in Section 7 when a formal statistical test is employed.

The results above indicate that at the aggregate level there is no difference between the EL and NEL conditions, and consequently the results are similar to those of the 48 tasks pooled together. It turns out that this also holds true for the

[4]The Matched-Pairs t-test looking at mean differences between the two common outcome tasks returns a p-value of 0.098 ($p = 0.109$) for the EL-condition (NEL). The Wilcoxon Matched-Pairs Signed-Ranks Test looking at median differences returns $p = 0.104$ for the EL-condition and $p = 0.102$ for the NEL-condition.

analysis at the individual level. Figures 6 and 7 below present the results according to the classification of individuals as loss seeking or loss averse using the two-tailed binomial test at the 5% significance level criterion (i.e., in 24 tasks 17 or more choices are in class).

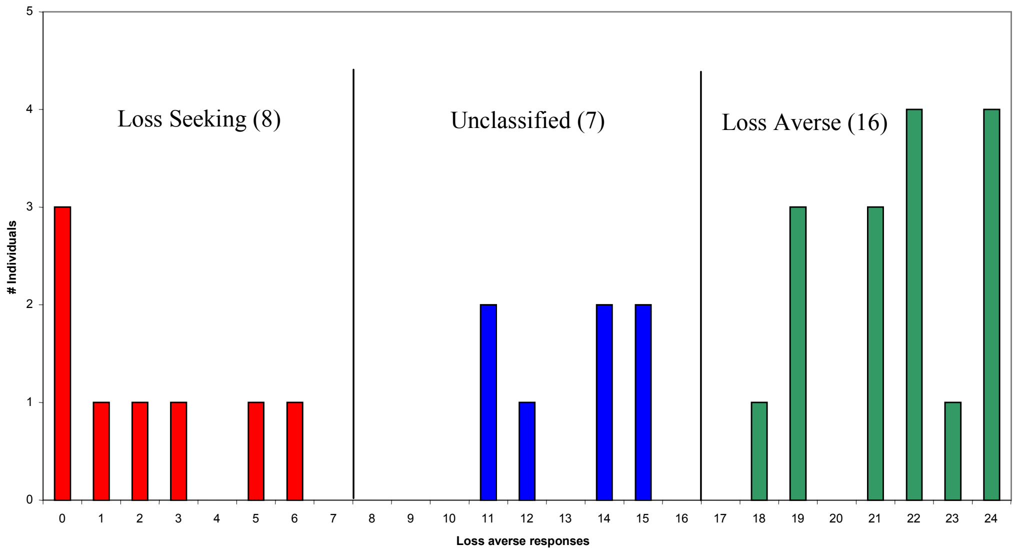

Figure 6: Classification According to Loss Attitude EL-condition

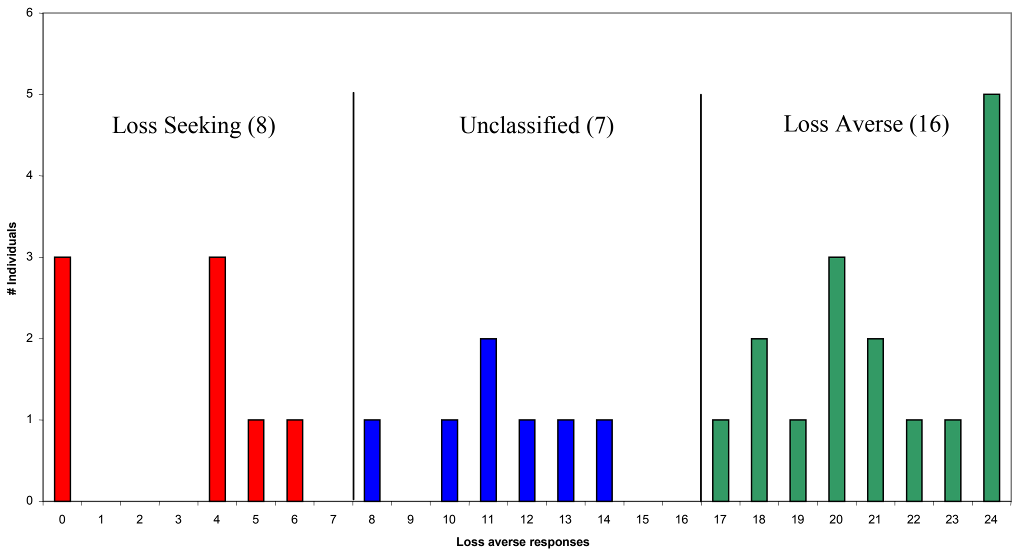

Figure 7: Classification According to Loss Attitude NEL-condition

In the EL-condition there are 8 loss seekers and 16 loss averters, leaving 7 individuals unclassified. A similar distribution is observed in the NEL-condition with some within class variation. As it turns out loss seekers in the EL condition are also loss seekers in the NEL-condition. Similarly, 15 loss averters in the EL-condition are also loss averters in the NEL-condition. Two individuals exhibit marginally inconsistent behavior, one by moving from unclassified in the EL-condition to loss averse in the NEL-condition and one from loss averse to unclassified. Both individuals are classified as loss averse if the data across the two conditions are pooled together. Again this confirms that the qualitative aspect of the results across the 48 loss attitude tasks remains unchanged if the analysis is conducted separately in the two conditions.

Recall that in the derivation of the previous results we included all 31 individuals participating in the study. Next we address the question of whether removing individuals that can be regarded as submitting inconsistent choices affects the above findings. As it turns out, removing individuals who reverse their preference in more than 3 out of the 10 repeated tasks, does not change the qualitative aspect of the above results.

The number of participants with consistent preferences is 20. Across the 48 loss attitude tasks 57.4% of the choices are in the direction of loss aversion, somewhat lower than for the whole population. Tables 3 and 4 are the analog to Tables 1 and 2, respectively.

Question	Left Outcomes			# Left Responses	# Right Responses	Right Outcomes		
1	10	0	-10	**8**	**12**	9	0	-9
2	9	0	-9	**9**	**11**	8	0	-8
3	8	0	-8	**8**	**12**	7	0	-7
4	7	0	-7	**9**	**11**	6	0	-6
5	6	0	-6	**7**	**13**	5	0	-5
6	5	0	-5	**8**	**12**	4	0	-4
7	4	0	-4	**7**	**13**	3	0	-3
8	3	0	-3	**7**	**13**	2	0	-2
9	2	0	-2	**10**	**10**	1	0	-1
10	10	3	-10	**10**	**10**	9	3	-9
11	9	3	-9	**11**	**9**	8	3	-8
12	8	3	-8	**12**	**8**	7	3	-7
13	7	3	-7	**7**	**13**	6	3	-6
14	6	3	-6	**6**	**14**	5	3	-5
15	10	5	-10	**9**	**11**	9	5	-9
16	9	5	-9	**10**	**10**	8	5	-8
17	8	5	-8	**12**	**8**	7	5	-7
18	7	5	-7	**11**	**9**	6	5	-6
19	10	7	-10	**8**	**12**	9	7	-9
20	10	-3	-10	**8**	**12**	9	-3	-9
21	9	-3	-9	**7**	**13**	8	-3	-8
22	8	-3	-8	**7**	**13**	7	-3	-7
23	7	-3	-7	**5**	**15**	6	-3	-6
24	6	-3	-6	**6**	**14**	5	-3	-5
		Aggregate %		**42.08**	**57.92**			

Table 3: Consistent Sample: Loss Attitude Tasks and Choices EL-condition

Question	Left Outcomes			# Left Responses	# Right Responses	Right Outcomes		
25	10	9	-10	**9**	**11**	9	9	-9
26	9	8	-9	**9**	**11**	8	8	-8
27	8	7	-8	**11**	**9**	7	7	-7
28	7	6	-7	**10**	**10**	6	6	-6
29	6	5	-6	**8**	**12**	5	5	-5
30	5	4	-5	**10**	**10**	4	4	-4
31	4	3	-4	**9**	**11**	3	3	-3
32	3	2	-3	**10**	**10**	2	2	-2
33	2	1	-2	**11**	**9**	1	1	-1
34	10	7	-10	**9**	**11**	9	7	-9
35	10	3	-10	**8**	**12**	9	3	-9
36	9	3	-9	**10**	**10**	8	3	-8
37	8	3	-8	**8**	**12**	7	3	-7
38	7	3	-7	**10**	**10**	6	3	-6
39	6	3	-6	**7**	**13**	5	3	-5
40	10	5	-10	**8**	**12**	9	5	-9
41	9	5	-9	**9**	**11**	8	5	-8
42	8	5	-8	**7**	**13**	7	5	-7
43	7	5	-7	**9**	**11**	6	5	-6
44	10	-3	-10	**6**	**14**	9	-3	-9
45	9	-3	-9	**6**	**14**	8	-3	-8
46	8	-3	-8	**8**	**12**	7	-3	-7
47	7	-3	-7	**9**	**11**	6	-3	-6
48	6	-3	-6	**6**	**14**	5	-3	-5
		Aggregate %		**43.13**	**56.88**			

Table 4: Consistent Subsample: Loss Attitude Tasks and Choices NEL-condition

There is a reduction in the number of tasks where choices are in agreement with loss aversion (70.83% compared to 89.58%). Note that with 20 individuals in some tasks we have an equal number of loss averse and loss seeking choices. This did not occur when we considered the full sample of 31 participants, where ties are impossible. If, in the analysis of the full sample we exclude tasks where choices are potential ties (16 vs 15) the the proportion tasks dominated by loss averse choices is 77.08%, which is still higher than 70.83% found for the consistent subsample. Note, however, in only 6 of the 48 tasks loss seeking preferences are dominant. According to Figure 8 the probability of choosing in agreement with loss aversion increases with the magnitude of the symmetric outcome of the left lottery. The jump at symmetric outcome 8 is not eliminated, and appears to be driven by having a positive common outcome in the lotteries of the corresponding tasks of the EL-condition (see tasks 12 and 17 in Table 3 above).

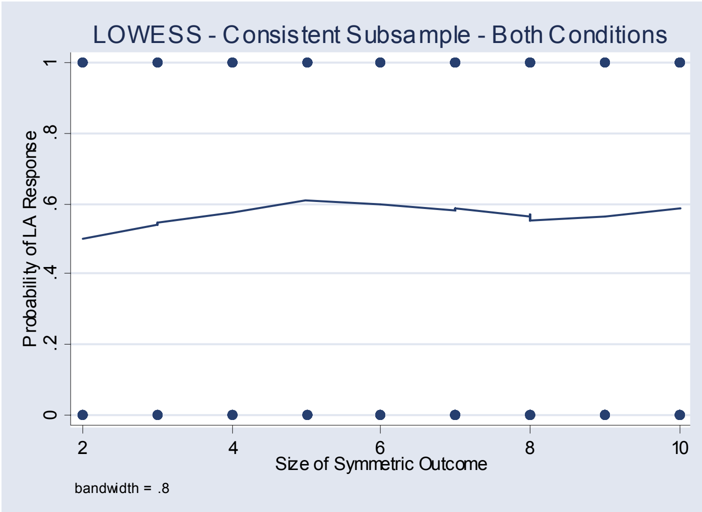

Figure 8: Consistent Sample LA/Symmetric Outcome

Accross all loss attitude tadks, if the common outcome is £3 then 55.5% choices are as predicted by loss aversion compared to 66% if the common outcome is £−3. The Matched-Pairs t-test looking at mean differences across the two common outcome tasks returns a p-value of 0.004. The Wilcoxon Matched-Pairs Signed-Ranks Test looking at median differences returns $p = 0.011$. Looking at the individual data, it turns out that, by leaving out individuals with inconsistent preferences, the ratio of loss averse and loss seeking individuals has decreased. Out of the 20 individuals 6 are loss seekers and 10 loss averters. The picture nearly remains identical if we restrict to the EL and NEL conditions (in the EL condition there are 9 loss averters and 5 unclassified individuals) showing that there is no significant difference between the two conditions.

Taken together these findings suggest that the adopted consistency rule is excluding loss averse individuals at a significantly higher rate than loss seekers or unclassified individuals, however, leaving loss averters in the majority (50% compared to 30% or 20%, respectively). In the next section we look at differences in risk behavior across gain lotteries and mixed-outcome lotteries. This allows us to infer whether the selection criterion used here is too harsh on loss averse individuals which have behavior that is risk neutral on gain lotteries, and thereby causing choice inconsistency. As can be seen in Table 5 below, 16 individuals are unclassified according to behavior on gain lotteries, hence are likely to exhibit risk neutral behavior. On average these individuals answer 63.13% of the repeated tasks consistently (101 of 160), however, looking only at loss attitude tasks they answer 75.34% of the repeated tasks consistently (55 of 73). Out of these individuals 9 are removed by the consistency rule adopted here: 5 are loss averters, 2 unclassified, and 2 loss seekers. As it turns out, with the exception of two individuals (one loss averter and one unclassified), these overal inconsistent individuals are answering nearly always consistent over loss attitude tasks. This fact should be taken into account when comparing the results on loss attitudes over the whole population with that if the consistent polulation.

5 Risk versus Loss Aversion

Recall that in the previous section we analyzed behavior on mixed lotteries only. We observed that statistically there is no significant difference between the EL-condition and the NEL-condition, and consequently no difference to the results of pooling the data together. In this section we look at the behavior on gain lotteries, and compare that to the results of loss attitudes in the EL-condition. We think that choosing the EL-condition as a reference is appropriate for two reasons. First, the number or MPS-tasks is 25 and therefore nearly identical to the number of loss attitude tasks in the EL-condition. Secondly most MPS-tasks have lotteries with equally likely probability for its outcomes. Replacing the data of the EL-tasks with the data of the NEL-tasks indeed does not affect our results.

Recall that a risk averse individual has a preference for the less spread lottery. Again we used a binomial test at the 5% level to classify individuals according to risk attitudes on gain lotteries. Table 5 below presents the distribution of risk averse, unclassified, and risk seeking individuals against the distribution of loss averse, unclassified, and loss seeking individuals, respectively.

Cross-Tab Full Sample - 5% level Classifications				
	RA	Unclassified	RS	Total
LA	7	8	1	16
Unclassified	4	2	1	7
LS	1	6	1	8
Total	12	16	3	31

Table 5: Risk vs Loss Attitude

Observe that the number of individuals which are unclassified according to risk attitudes is 16 and much larger than 7, the number of individuals which are unclassified according to loss attitude. The opposite pattern is observed when comparing the numbers of risk seeking individuals (3) with the number of loss seekers (8). Looking only at the unclassified group according to risk attitude on gains we observe a strong polarization effect: The majority of individuals (14) can be classified as loss seeker or loss averter, and the distribution into loss averters and loss seekers is roughly equal (8 and 6 respectively). Such a polarization effect is not observed for the risk averters and risk seekers. This polarization effect may be driven by the rule used to classify individuals into the risk attitude classes. Using the binomial test at 10% significance for the classification according to both, the risk attitude tasks and the loss attitude task in the EL-condition, shows that the polarization effect becomes weaker as half of the individuals move from the unclassified group into either the risk averse or risk seeking category (5 and 3, respectively). Table 6 below is the corresponding analog of Table 5.

Cross-Tab Full Sample - 10% level Classifications				
	RA	Unclassified	RS	Total
LA	10	5	1	16
Unclassified	5	1	1	7
LS	2	2	4	8
Total	17	8	6	31

Table 6: Risk vs. Loss Attitude 10% level

The overall impression is that risk attitudes vary strongly across the domain of lotteries, that is, when moving from gain lotteries to mixed lotteries.

If one thinks of risk attitude more broadly as a domain independent property, by combining attitudes in the MPS-tasks with loss attitude in the EL-condition into one category (that is, we neglect the sign of outcomes in the lotteries and treat all tasks as MPS-tasks), then the individuals here are classified as 20 risk averters and 6 risk seekers, leaving only 5 unclassified individuals. The high proportion of risk averters is in contrast to other findings regarding risk attitudes on small scale lotteries (e.g., Battalio, Kagel and Jiranyakul 1990, Hogarth and Einhorn 1990, Kachelmeier and Shehata 1992, Beattie and Loomes 1997, Holt and Laury 2002), and indicates that risk attitudes are strongly affected by having mixed lotteries.

Recall that the classification rule on consistent individuals adopted here is excluding more loss averse individuals compared to loss seekers. To complete the picture, we reconsider the above analysis for the 20 consistent individuals. Table 7 below shows the distribution of risk averse, unclassified, and risk seeking individuals against the distribution of loss averse, unclassified, and loss seeking individuals.

Cross-Tab Consistent Subsample - 5% level Classifications				
	RA	Unclassified	RS	Total
LA	5	3	1	9
Unclassified	4		1	5
LS	1	4	1	6
Total	10	7	3	20

Table 7: Risk vs Loss Attitude Consistent Sample

Observe that the number of individuals which are unclassified according to risk attitudes (7) is somewhat higher than the number of individuals which are unclassified according to loss attitude (5). Similarly this holds for the number of risk averters (10) compared to loss averters (9). There are no unclassified individuals according to both conditions, and risk and loss attitudes are varying independently. For example, of the 10 risk averse individuals 5 are loss averse and 1 is loss seeking, and of the 9 loss averters 5 are risk averse and 1 is risk seeking. The above mentioned polarization effect is also observed here: of the 7 unclassified individuals according to risk attitudes, 4 are loss seekers and 3 are loss averters. This polarization is less pronounced if the 10% level is used in the binomial test, as the next table shows:

Cross-Tab Consistent Subsample - 10% level Classifications				
	RA	Unclassified	RS	Total
LA	6	2	1	9
Unclassified	4		1	5
LS	2	1	3	6
Total	12	3	5	20

Table 8: Risk vs Loss Attitude Consistent Sample

Notice that the classification according to loss attitudes remains unaffected by the change in significance level from 5% to 10%.

Looking at risk attitude by combining attitudes in the MPS-tasks with loss attitudes in the EL-condition, the consistent individuals are classified as 12 risk averters and 4 risk seekers, leaving only 4 unclassified individuals (according to the binomial test at the 5% level). The proportion of risk averters in the consistent subsample (60%: 12 out of 20) is only marginally lower than the proportion of risk averters in the whole population (64.5%: 20 out of 31).

The results for the whole population are insignificantly different from those where the inconsistent individuals are excluded. The results in this section show that behavior depends strongly on the domain over which lotteries are defined. Edwards (1962) has already distinguished between probability weighting for gain lotteries, mixed lotteries, and loss lotteries. In original prospect theory (Kahneman and Tversky 1979) lotteries are evaluated by different functionals depending on these domains. Schoemaker (1990) also proposes a similar distinction, and finds a high proportion of risk aversion over hypothetical gain lotteries and mixed lotteries. In contrast Battalio, Kagel, and Jiranyakul (1990) find much lower proportions of risk averse choices over gain lotteries compared to choices over mixed lotteries (comparing their Table 3 and Table 4).

6 Gender Effects

In this section we separate individuals according to gender. Recall that the binomial test at the 5% level is used to classify individuals. Of the 31 participants in the study 18 are males. The table below shows the distribution of risk averse, unclassified, and risk seeking individuals against the distribution of loss averse, unclassified, and loss seeking individuals for the female and male subsample, respectively.

Cross-Tab Full Sample - Female - 5% level Classifications				
	RA	Unclassified	RS	Total
LA	4	5		9
Unclassified	1	2		3
LS	1			1
Total	6	7		13

Cross-Tab Full Sample - Male - 5% level Classifications				
	RA	Unclassified	RS	Total
LA	3	3	1	7
Unclassified	3		1	4
LS		6	1	7
Total	6	9	3	18

Table 9: Risk vs Loss Attitude: Female vs. Male

Comparing the distribution according to loss attitudes in the last columns shows that most women are loss averse (69.23%) and that men are equally divided into loss averters and loss seekers. Accordingly, a polarization effect for the individuals unclassified according to risk attitudes is observed only for men. Most women that are unclassified according to risk attitude become loss averters, and there are no risk or loss seeking women. In contrast, proportionally more men, which are unclassified according to risk attitude, become loss seekers. This explains the polarization effect observed in Section 5 (see Table 5 above). Looking at risk attitudes by combining the MPS-tasks and the loss attitude tasks of the EL-condition shows that of the 13 women, 11 are risk averse (0 are risk seeking), and of the 18 men 9 are risk averse (6 are risk seeking).

The picture remains roughly the same if we look at the consistent individuals, as the next table shows.

Cross-Tab Consistent Subsample - Female - 5% level Classif				
	RA	Unclassified	RS	Total
LA	3	3		6
Unclassified	1			1
LS	1			1
Total	5	3		8

Cross-Tab Consistent Subsample - Male - 5% level Classifica				
	RA	Unclassified	RS	Total
LA	2		1	3
Unclassified	3		1	4
LS		4	1	5
Total	5	4	3	12

Table 10: Consistent Individuals Risk vs Loss Attitude Female vs Male

Looking at risk attitudes by combining all 49 tasks shows that of the 8 women 7 are risk averse (0 are risk seeking), and of the 12 men 5 are risk averse (4 are risk seeking).

The results show that women exhibit more loss averse behavior than men in the domain of mixed lotteries, and also women are comparatively more risk averse on gain lotteries. Using utility as a measure for loss attitude, Schmidt and Traub (2002) also find that women are more loss averse. Several other studies support the view that women are more risk averse than men (for a review and discussion on appropriate risk measures see Powell, Schubert, and Gysler (2001)).

7 Common Outcomes

In the previous sections we have provided evidence in support of loss aversion. Also, we observed that loss aversion is influenced by the sign of common outcomes in a pair of lotteries, and that gender is also influencing loss attitude. In this section we conduct a formal statistical analysis looking jointly at these effects by employing a random effects probit regression. For this analysis only the loss attitude tasks are employed. We included the following variables in the regression: LSYMOUT is the value of the larger symmetric outcome within a loss attitude task, LSYMOUTSQ is the square of LSYMOUT, SIGNCOMOUT is a dummy for the sign of the common outcome in a task (taking value 0 if the common outcome is negative), PROBDIST is a dummy variable for the probability distribution (taking value 1 in the EL-condition), and GENDER is a dummy taking value 1 for male individuals. The output of the regression is presented in Table 11:

Random Effects Probit	All Subjects		
Variable	**Coeff**	**Std Err**	**p-value**
LSymOut	0.0379	0.1	0.705
LSymOutSq	0.00002	0.008	0.998
Gender	-1.098	0.104	0.000
ProbDist	0.068	0.083	0.417
SignComOut	-0.315	0.107	0.003
Constant	0.601	0.344	0.082
Rho	0.578	0.03	0.000
N	1488		
Log-Likelihood	-636.839		
Model Chi-Sq	123.72		0.000

Table 11: Random Effects Probit Regression

Confirming the results of the previous sections, this regression shows that GENDER and SIGNCOMOUT are significantly influencing loss attitudes. Females are more likely to choose in accordance with loss aversion. Also, a negative common is increasing the probability of a loss averse choice. Looking at a loss attitude task, the absolute value of the symmetric outcome in the more spread lottery increases the likelihood of a loss averse choice, but this effect is not significant. When looking at the probability of the symmetric outcomes in a lottery, we observe a positive relationship between the likelihood of a loss averse choice and the likelihood of the symmetric outcomes, although this effect is also not significant. Studies focusing on probability weighting have normally found overweighting and underweighting of probabilities close to 0 and 1. For the probabilities used here (1/3 and 1/4) these studies suggest that no significant distortion takes place. From this point of view the low significance for the effect of probability of symmetric outcomes is not surprising.

The analog regession for consistent individuals gives similar results. We present these in the table below.

Random Effects Probit		Consistent Subjects	
Variable	**Coeff**	**Std Err**	**p-value**
LSymOut	0.092	0.131	0.482
LSymOutSq	-0.008	0.01	0.443
Gender	-1.165	0.126	0.000
ProbDist	0.061	0.108	0.574
SignComOut	-0.502	0.14	0.000
Constant	0.884	0.455	0.052
Rho	0.585	0.032	0.000
N	960		
Log-Likelihood	-383.045		
Model Chi-Sq	95.88		0.000

Table 12: Random Effects Probit Regression

Table 12 shows that the sign of the common outcome in the lotteries within a task is highly significant for loss attitude, and similarly this holds for gender. Compared to Table 11 above, the absolute value of coefficients of the signifficant variables is slightly larger.

8 Conclusion

Theoretical analyses of loss attitude have focused on properties of the utility function in the spirit of Markowitz (1952) and Kahneman and Tversky (1979), and consequently view loss aversion as model specific (e.g., Wakker and Tversky 1996, Schmidt and Traub 2002, Neilson 2002, Köbberling and Wakker 2003). In this paper we have proposed a behavioral condition for loss aversion and constructed an experiment in which the property is tested. Loss aversion entails trading off a potential marginal gain against an equally likely marginal loss of the same magnitude. In the experiments considered here, this marginal change has been rather small (i.e., always £1). Nevertheless, loss aversion has been observed as the predominant behavior at the aggregate level, and indeed a majority of individuals can be classified as loss averse. Other studies looking at loss aversion have used different measures, different classes of lotteries and outcomes, and sometimes hypothetical payoffs. This makes it difficult to relate those results to our findings. The common finding however, is that loss aversion is observed as a dominant feature.

The tasks on loss attitudes involve mixed lotteries where both, gains and losses, are among the potential outcomes. The symmetry requirements in the condition for loss aversion combined with the likelihood of outcomes distinguishes our study from previous experiments. When looking at risk attitudes on gain lotteries we observe that risk neutral behavior dominates at the individual level, as the majority of individuals cannot be classified as risk averse or risk seeking. The shift from gain lotteries to mixed lotteries induces more risk aversion, and confirms that risk attitudes vary depending on the domain of outcomes.

The common outcomes in the tasks on loss attitudes have a strong influence on behavior. Loss aversion becomes more pronounced as the common outcome is negative. This effect is in contrast to comonotonic independence, and it highlights the role of probabilities for loss attitude. That violations of comonotonic independence are equally frequent as violations of non-comonotonic independence has been observed earlier by Wakker, Erev, and Weber (1994). More recently, Birnbaum and Navarette (1998) have found violations of the principle when common outcomes are best or worst. The evidence from our study complements their finding as the common outcomes are in the middle range. Our finding suggests that loss attitudes may depend on the likelihood of losing (or gaining), and is related to psychological arguments favoring a decomposition of a lottery into a gain and a loss part which are evaluated separately before determining the final value the lottery (see Hogarth and Einhorn 1990, Luce 1991, Luce and Fishburn 1991). How precisely the integration of the two parts should take place, and what role should be assigned to loss attitude in that process, is yet an open question and we think in need of further investigation (see also Luce 2000).

The range of probabilities used in the lotteries is rather small. How loss attitudes emerge when the probabilities of symmetric outcomes are smaller than 1/4 is unclear. As this is the domain where most sensitivity towards probability is observed (Hogarth and Einhorn 1990, Tversky and Kahneman 1992, McClelland, Schulze, and Coursey 1993, Wu and Gonzalez 1996, Wu and Gonzalez 1998, Abdellaoui

2000, Jullien and Salanié 2000, and Abdellaoui, Vossmann, and Weber 2003), it is instructive to test loss aversion in that domain. Variations in the magnitude of symmetric outcomes and in the marginal gain-loss trade-offs are subsequent directions of study.

We consider loss aversion as a behavioral property that has different implications across decision models. Our study has been conducted on small outcome lotteries with real gain and loss outcomes, and the findings have contributed to a more detailed picture of loss aversion.

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Appendix: Tasks and Instructions

Task	Outcomes in left Lottery			Outcomes in right lottery			Condition
	Left	Middle	Right	Left	Middle	Right	
1	10	0	-10	9	0	-9	EL
2	9	0	-9	8	0	-8	EL
3	8	0	-8	7	0	-7	EL
4	7	0	-7	6	0	-6	EL
5	6	0	-6	5	0	-5	EL
6	5	0	-5	4	0	-4	EL
7	4	0	-4	3	0	-3	EL
8	3	0	-3	2	0	-2	EL
9	2	0	-2	1	0	-1	EL
10	10	3	-10	9	3	-9	EL
11	9	3	-9	8	3	-8	EL
12	8	3	-8	7	3	-7	EL
13	7	3	-7	6	3	-6	EL
14	6	3	-6	5	3	-5	EL
15	10	5	-10	9	5	-9	EL
16	9	5	-9	8	5	-8	EL
17	8	5	-8	7	5	-7	EL
18	7	5	-7	6	5	-6	EL
19	10	7	-10	9	7	-9	EL
20	10	-3	-10	9	-3	-9	EL
21	9	-3	-9	8	-3	-8	EL
22	8	-3	-8	7	-3	-7	EL
23	7	-3	-7	6	-3	-6	EL
24	6	-3	-6	5	-3	-5	EL

Task	Outcomes in left Lottery			Outcomes in right lottery			Condition
	Left	Middle	Right	Left	Middle	Right	
25	10	9	-10	9	9	-9	NEL
26	9	8	-9	8	8	-8	NEL
27	8	7	-8	7	7	-7	NEL
28	7	6	-7	6	6	-6	NEL
29	6	5	-6	5	5	-5	NEL
30	5	4	-5	4	4	-4	NEL
31	4	3	-4	3	3	-3	NEL
32	3	2	-3	2	2	-2	NEL
33	2	1	-2	1	1	-1	NEL
34	10	7	-10	9	7	-9	NEL
35	10	3	-10	9	3	-9	NEL
36	9	3	-9	8	3	-8	NEL
37	8	3	-8	7	3	-7	NEL
38	7	3	-7	6	3	-6	NEL
39	6	3	-6	5	3	-5	NEL
40	10	5	-10	9	5	-9	NEL
41	9	5	-9	8	5	-8	NEL
42	8	5	-8	7	5	-7	NEL
43	7	5	-7	6	5	-6	NEL
44	10	-3	-10	9	-3	-9	NEL
45	9	-3	-9	8	-3	-8	NEL
46	8	-3	-8	7	-3	-7	NEL
47	7	-3	-7	6	-3	-6	NEL
48	6	-3	-6	5	-3	-5	NEL

Task	Outcomes of left Lottery			Outcomes of right Lottery			Condition
	Left	Middle	Right	Left	Middle	Right	
49	8	9	6	7	10	6	EL
50	5	9	6	7	10	3	EL
51	6	8	2	9	6	1	EL
52	6	5	2	9	3	1	EL
53	12	4	8	6	5	13	EL
54	12	5	5	3	5	13	EL
55	11	8	2	10	4	7	EL
56	9	8	2	10	4	5	EL
57	14	11	3	15	7	6	EL
58	14	9	3	15	5	6	EL
59	13	8	11	7	15	10	EL
60	13	8	9	5	15	10	EL
61	8	7	5	3	9	6	NEL
62	5	7	5	3	9	3	NEL
63	5	8	4	6	6	6	NEL
64	5	5	4	6	3	6	NEL
65	7	8	8	6	10	6	NEL
66	7	8	5	3	10	6	NEL
67	11	6	11	14	7	7	NEL
68	9	6	11	14	7	5	NEL
69	9	11	1	13	7	5	NEL
70	9	9	1	13	5	5	NEL
71	9	8	11	7	12	7	NEL
72	9	8	9	5	12	7	NEL

Task	Outcomes of left Lottery			Outcomes of right Lottery			Condition
	Left	Middle	Right	Left	Middle	Right	
73	8	1	0	6	2	1	EL
74	5	1	0	3	2	1	EL
75	9	8	4	13	6	2	EL
76	9	5	4	13	3	2	EL
77	10	9	8	14	7	6	EL
78	10	9	5	14	7	3	EL
79	11	2	1	7	4	3	EL
80	9	2	1	5	4	3	EL
81	13	11	1	14	7	4	EL
82	13	9	1	14	5	4	EL
83	13	12	11	15	14	7	EL
84	13	12	9	15	14	5	EL
85	8	2	2	6	3	3	NEL
86	5	2	2	3	3	3	NEL
87	8	8	0	7	6	3	NEL
88	8	5	0	7	3	3	NEL
89	8	8	8	14	6	6	NEL
90	8	8	5	14	6	3	NEL
91	11	4	3	7	5	5	NEL
92	9	4	3	5	5	5	NEL
93	11	11	1	15	7	5	NEL
94	11	9	1	15	5	5	NEL
95	11	11	11	13	12	7	NEL
96	11	11	9	13	12	5	NEL

Experiments on Individual Choice

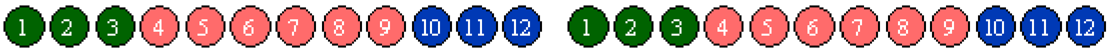
(This experiment has been approved by the Senate Committee on the Ethics of Research on Human Beings of the University of Manchester)

Welcome to this session. The aim of this experiment is to investigate how people make decisions. We will ask you to make several decision, and will record your choice. The records will be used for scientific purposes only. Our published results will not identify any individuals. Our general interest is to observe and analyse how people make decisions. We expect that 50 or more people will participate in this experiment.

This experiment is not a test. There is no way for us to tell whether your decisions are good or bad. That is for you to judge. People are different, and faced with the same situation they will prefer to take different courses of action. What you need to consider is the fact that the amount of money that you receive depends partly on your decisions, and partly on luck.

We will ask you to perform 106 tasks. Each task consists of choosing one of two gambles. The gamble that you have chosen will be played. An example of a task is described below:

Choose the gamble that you would like to play:



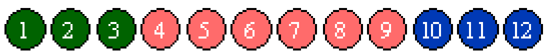
7 3 0 5 1 3

○ left ○ right

Submit

After deciding which gamble to play by marking "left" or "right" and pressing the "Submit" button the next task appears.

Now we explain what a gamble is and how it is played. A complete gamble is visualised on the screen as 12 balls numbered consecutively from 1 to 12 with amounts of money underneath balls of the same colour. An example is the following gamble:



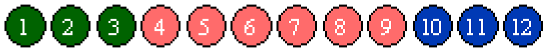
7 6 2

This is how a gamble is played: A bag contains all 12 balls. One ball is drawn at random. Each ball in the bag is equally likely to be drawn. You will be paid the amount of money indicated underneath the drawn ball.

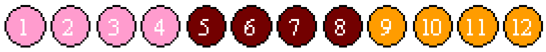
In the example above, the **green balls** indicates that **£7.00** will be paid for a ball with the number **1, 2, or 3** on it. The **red balls** indicates that **£6.00** will be paid for a ball with the number **4, 5, 6, 7, 8, or 9** on it. And the **blue balls** indicates that **£2.00** will be paid for a ball with the number **10, 11, or 12** on it.

In this experiment there will be two types of gambles:

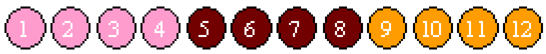
Gamble type 1: A bag contains 12 balls numbered from 1 to 12. One ball is drawn at random. Each ball in the bag is equally likely to be drawn. If the ball is numbered **1, 2, or 3** you receive the amount of money indicated underneath those balls (therefore, there is a **25%** chance of getting that amount). If the ball is numbered **4, 5, 6, 7, 8, or 9**, you receive the amount of money indicated underneath those balls (therefore, there is a **50%** chance of getting that amount). If the ball is numbered **10, 11, or 12**, you receive the amount of money indicated underneath those balls (therefore, there is a **25%** chance of getting that amount). We represent this gamble with balls coloured **green**/**red**/**blue**, as follows:



Gamble type 2: A bag contains 12 balls numbered from 1 to 12. One ball is drawn at random. Each ball in the bag is equally likely to be drawn. If the ball is numbered **1, 2, 3, or 4** you receive the amount of money indicated underneath those balls (therefore, there is a **33.33%** chance of getting that amount). If the ball is numbered **5, 6, 7, or 8**, you receive the amount of money indicated underneath those balls (therefore, there is a **33.33%** chance of getting that amount). If the ball is numbered **9, 10, 11, or 12**, you receive the amount of money indicated underneath those balls (therefore, there is a **33.33%** chance of getting that amount). We represent this gamble with balls coloured **pink**/**brown**/**orange**, as follows:



Some gambles involve negative amounts of money. In such a gamble you may lose some amount of money from the fixed payment (£10.00) that you receive if you complete all tasks. For example the gamble below indicates that you can either lose £7.00 with 33.33% chance, or lose £6.00 with 33.33% chance, or win £2.00 with 33.33% chance.



-7 -6 2

If you complete all tasks, then you receive a participation fee of £10.00 plus an additional amount of money determined by your decision in one randomly selected task. The computer will select this answer after all tasks have been completed. The additional amount of money ranges from £-10.00 to £15.00. Therefore the final sum of money that you receive will be a positive amount in the range of £0.00 and £25.00; it will never be negative.

Take your time to make sure that you have understood everything. The window with these instructions will be accessible at all times. You may also ask the experimenters for help. Please do **not use the "Back" button** of your internet browser unless you are asked on the computer screen. Also, please do not distract (or talk to) other people taking part in the experiment. If you completed all tasks please remain seated and indicate to the experimenter that you have finished.

When you are ready to start with the tasks, press the "Proceed with the Experiment" link below, and then follow the instructions set by the computer.

Proceed with the experiment